# Sometimes Nature Doesn't Work: Absence of Attention Restoration in Older Adults Exposed to Environmental Scenes

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**Abstract**

*Background/Study Context*: An accumulating body of literature indicates that contact with natural settings can benefit health and wellbeing. Numerous studies support Attention Restoration Theory (ART), which suggests that even short exposure to nature, as opposed to urban environments, can promote attention restoration by stimulating soft fascination. However, it is unclear whether the restorative effects hold in aging. This study tested nature effect on cognitive restoration in older people..

*Methods*: Utilizing the Sustained Attention to Response Task (SART), we explored changes in attentional performance in 75 healthy older individuals before and after exposure to either natural or urban scenes. We checked for age-related differences by comparing the older sample to a group of 21 young participants.

*Results*: We found no effects of environmental exposure for either attentional accuracy, sensitivity to visual targets or reaction times. Our older participants had worse accuracy and slower reaction times than a younger control group who used the same paradigm.

*Conclusion*: The results of our study conducted with older adults show no attention restoration effects in this population. Potential geographical/cultural moderators as well as methodological considerations are discussed to provide insights for future studies on cognitive restoration in older age.

*Keywords*: directed attention; restorative environments; aging; nature, urban.

## Introduction

An ever-growing body of literature indicates that exposure to nature can have salutogenic effects on both physical and cognitive health (Berto, 2014; Beute & de Kort, 2014; Bratman, Hamilton, & Daily, 2012; de Keijzer, Gascon, Nieuwenhuijsen, & Dadvand, 2016; Gascon et al., 2015; Ohly et al., 2016; van den Bosch & Ode Sang, 2017). Attention Restoration Theory (ART, Kaplan, 1995) suggests that nature has a positive impact on cognition because it provides relief from attentional fatigue: According to ART, natural green spaces engage bottom-up involuntary attention (defined as "soft fascination") while reducing the burden on top-down (or directed) attentional demands; on the contrary, urban environments offer complex perceptual stimulation which might result demanding for directed attention ("hard fascination"), and possibly detrimental to it (Berman, Jonides, & Kaplan, 2008; Kaplan & Berman, 2010). ART has found support not only in behavioural research, but also in neuroimaging studies: These have associated exposure to nature, as compared to urban images, with selective activation of brain areas involved in involuntary rather than voluntary attention (Martínez-Soto, Gonzales-Santos, Pasaye, & Barrios, 2013), as well as with enhanced connectivity in sensory areas, which has been interpreted as less effortful processing (Chen, He, & Yu, 2016).

The majority of studies on ART have focused on younger populations, while very few have attempted to demonstrate cognitive restoration in older individuals, showing some attentional benefits of exposure to nature in healthy and clinical populations (Dahlkvist et al., 2016; de Keijzer et al., 2016; Eggert et al., 2015; Gamble, Howard, & Howard, 2014; Ottosson & Grahn, 2005, 2006), using either in vivo exposure or image viewing. The restorative effects of walking in nature have also been shown in older adults using wearable electroencephalography, although these studies did not test attention specifically (Neale et al., 2017; Tilley, Neale, Patuano, & Cinderby, 2017). Gamble et al. (2014) presented pictures of natural vs. urban scenes for six minutes to older and younger adults (7 seconds per picture), and found no effect for alerting and orienting, but an effect on executive attention (measured through the Attention Network Task) whereby performance in the last block pre-exposure and the first block post-exposure was improved in the nature group only; there was also no age difference or interaction in the task. Considering the increased susceptibility to environmental stimulation with aging (Lawton & Nahemow, 1973; Wahl & Oswald, 2010), understanding how nature impacts cognition in older age can help to design environments that support older individuals' mental well-being in an increasingly urbanized world (Cassarino & Setti, 2015; Finlay, Franke, McKay, & Sims-Gould, 2015; World Health Organization, 2007).

One type of attention that is susceptible to cognitive restoration in young adults (Berto, 2005) and is subjected to change with ageing is sustained attention (Carriere, Cheyne, Solman, & Smilek, 2010; McAvinue et al., 2012; Staub, Doignon-Camus, Després, & Bonnefond, 2013). Sustained attention refers to the capacity to self-sustain attentional focus for a relatively prolonged period of time. Surprisingly, sustained attention has received little attention in the existing literature: A recent systematic review of over 30 studies testing ART (Ohly et al., 2016) included only one experimental study that used a measure of sustained attention, the Sustained Attention to Response Task, or SART, with a young sample (Berto, 2005). This could be due to the fact that tasks of sustained attention are less cognitively demanding for a younger individual than tasks using more executive functions such as the backwards digit span (Ohly et al., 2016). Sustained attention has however been linked to performance decline over the lifespan, as shown in a study by McAvinue et al. (2012) that employed the SART. Older adults tend to favor accuracy over speed in timed sustained attention tasks, showing that, while this component of attention is relatively spared by ageing, compensation strategies are necessary to complete the task (Staub et al., 2013). However, Gamble et al. (2014) found no restorative effects on alertness (which is related to sustained attention) in an older group, thus warranting further investigation of the potential restorative effects of nature on sustain attention in older age.

The present study aimed to test the effects on sustained attention of viewing images of natural or urban environments in a sample of healthy older individuals with a paradigm that was shown to be effective in young adults, the Sustained Attention to Response Task, or SART (Berto, 2005). The SART tests alertness over time, as well as the ability to inhibit an automatic response to a target stimulus, and it causes mental fatigue, representing therefore a suitable measure of directed attention (Berto, 2005). Interestingly, performance at the SART correlates with self-reports of attentional failures (Robertson et al., 1997), indicating that what is assessed by the SART has real-life relevance. In her study, Berto (2005) found no variation in performance in the group exposed to urban images, while she found improvements in terms of target sensitivity, reaction times and accuracy in the group exposed to green scenes. We hypothesized, based on Berto's (2005) results on young adults, that SART performance would remain stable for the group of older people exposed to urban scenes (low restoration) and would improve in the group exposed to green scenes (high restoration). Alternatively, if, like alertness, sustained attention is not improved by viewing restorative pictures, we would expect no restoration effects or, potentially a decrease in performance due to fatigue. To check for age-related differences, we also tested a group of young adults with the same paradigm to confirm that older adults' performance was poorer in older than younger individuals.

# Methods

## Participants

A sample of 75 healthy community-dwelling Irish older people aged 60 years and older were recruited through convenience sampling and snowballing in urban and rural areas of the South/West region of the Republic of Ireland. Prospective participants were included in the study if showing absence of cognitive impairment measured as a score of 25 or higher at the Short Mini Mental State Examination (SMMSE, Molloy & Standish, 1997). We initially enrolled 85 prospective participants, however, 10 were excluded from the analyses due to withdrawal (n = 2), a total score of less than 25 at SMSSE (n = 3), or issues with understanding the task in the SART (n = 5). In addition, we tested 21 younger individuals (Mean age = 21.48, *SD* = 7.09; 57.1% female) to check for potential age-related differences in the SART between younger and older. The younger sample was composed of university students recruited aged 18 years and older through convenience sampling and snowballing. All participants (young and older) read and signed a consent form prior to participation.

Ethical approval for this study was received by the School of Applied Psychology Ethics Committee, University College Cork, Ireland.

## Design

In line with Berto (2005), environmental scenes were selected prior to the study based on ratings of their restorative potential. In the experimental part of the study, a mixed 2 (SART session: pre-, post-images viewing) X 2 (Exposure group: natural, urban) design was adopted to explore exposure effects on performance at the SART. The SART session varied within subjects as changes in sustained attention performance, whereas exposure group varied between subjects.

## Material and Measures

### Selection of images and rating of restorativeness

Prior to the study, we selected 30 pictures of environmental scenes freely available on the Internet, half depicting urban scenes and half of natural settings. Images containing human figures and/or clear written material such as signs were excluded to reduce distractibility (Berto, 2005); in addition, pictures including water were not used given the potential for differential restorative properties of blue and green spaces (Gascon, Zijlema, Vert, White, & Nieuwenhuijsen, 2017). Natural settings included green scenes with trees and urban settings included scenes with buildings and/or city streets. As Gatersleben & Andrews (2013) suggest that wild nature (i.e., forests) might not be as restorative as open green areas, we included a variety of images in our initial pool. Using existing scales of perceived restorativeness, a 6-item survey (see Supplementary File 1) was administered to university students and members of staff ($N$ = 211; mean age = 37.3, $SD$ = 14.54, range = 18 – 72 years; 66% female) to rate each picture with regards to the following qualities: fascination, being away, and coherence (Hartig, Korpela, Evans, & Gärling, 1997; Korpela & Hartig, 1996), scope (Pasini, Berto, Brondino, Hall, & Ortner, 2014), and familiarity (Purcell, Peron, & Berto, 2001). Short forms of the PRS have been used successfully in previous studies (Berto, 2005). We decided to include two items on fascination, as this is a key aspect of environmental scenes that elicits involuntary rather than directed attention (Berto, Baroni, Zainaghi, & Bettella, 2010; Berto, Massaccesi, & Pasini, 2008), and therefore more in line with our research question. Analysis of the survey through Cronbach's alpha indicated a level of reliability equal to .96.

Following analysis of the ratings for each scene, three pictures which showed significant age-related differences in ratings were removed. The remaining pictures were sorted based on their mean level of restorativeness, and a total of 16 images were retained for use in the study: These included urban scenes, which had received the lowest ratings of perceived restorativeness ($M$ = 3.66, $SD$ = 0.93), and eight images of natural settings, which had the highest ratings ($M$ = 6.98, $SD$ = 1.27). The differences in perceived level of restorativeness between the two groups of images were statistically significant, $t_{139}$ = 18.89, $p$<.000, Cohen's $d$ = 1.60. We selected fewer images than done in previous studies (Berto, 2005) in order to facilitate older participants with a shorter duration of the experiment, based on pilot work on SART with an older population. The images used in the experimental study are included in Supplementary File 1.

**Sustained attention to response task (SART)**

The SART is an experimental paradigm used to measure sustained attention (Robertson et al., 1997). In this task, participants viewed a sequence of digits appearing on a computer screen, and were asked to press the spacebar on the keyboard as quickly as possible at the appearance of each digit, with the exception of the digit three, therefore testing the ability of participants to inhibit a repetitive response in the presence of the target stimulus (i.e., the digit three). The task was run using the E-Prime 2.0 software on a HP Pavilion g6-1A69US laptop computer with a 15.6-inch glossy 720p display (1,366 X 768 resolution). In the present version of the SART, the task begun with a practice trial including 18 digits (two of each digit between one and nine), followed by a test trial in which 171 digits (19 of each digit between one and nine) were presented in one of five semi-randomly assigned fonts in the range of 12-29 millimeters. In the test trial, the target stimulus appeared 19 times, while the remaining 152 digits were non-lures (digits one to nine other than three). Digits appeared on the screen every 1,125 milliseconds, for the duration of 250 milliseconds each, followed by a 900 milliseconds mask constituted of a diagonal cross contained within a 29 millimeters ring. The duration of 250 milliseconds was also pilot tested and was considered the shortest possible to increase the need to sustain attention and allow comparison with younger adults with no ceiling effects. Both the digits and the mask were white against a black background. Instructions on how to complete the task were showed on the computer screen prior to the appearance of both the practice and the test trial. The used version of the SART was shorter than the version employed by Berto (2005) to allow older participants to complete the task without distress.

**Procedure**

Participants were tested individually in one of the labs at the University or in a quiet space at a community center. Each participant read and signed a consent form, and was screened with the SMMSE. They completed Session 1 of the SART, which lasted approximately five minutes. They then viewed eight images of either natural or urban environmental scenes, presented for 15 seconds each on a slideshow on the computer screen. Images were shown in the same pre-set order for all participants within each exposure group. As per Berto (2005), participants were instructed to view the images freely and were informed that no questions or tasks would be related to the content of the slideshow. After the slideshow, they completed Session 2 of the SART. In the final part of the experiment, participants provided information about their socio-demographic status, health, and place of residence via a survey.

**Statistical analyses**

Analyses were conducted using the statistical software IBM SPSS version 24. Participants’ performance at the SART was analyzed in terms of d-prime (sensitivity index), reaction times (in milliseconds) of correct responses, mean accuracy (the proportion of correct responses for lures and non-lures combined), errors of omission (errors on non-lures: not pressing the spacebar when due), errors of commissions (errors on lures: pressing the spacebar in the presence of the number three), and inverse efficiency (i.e., reaction times over accuracy for non-lures).

A test of normality was carried for all measures by exposure group using the Shapiro-Wilk test (see Supplementary File 2): d-prime and reaction times in both sessions (pre- and post-viewing) were the only measures meeting the assumption of normality for both exposure groups. Therefore, normally distributed variables were described through mean (*M*) and standard deviation (*SD*) while descriptive statistics for non-normally distributed variables were presented as median and interquartile range (IQR).

Between-groups differences in SART performance pre- and post-image exposure were tested through an independent samples t-test for normally distributed measures, and through the Mann-Whitney test for measures that did not meet the assumptions of normality. Within-group changes in SART performance were tested through a paired-samples t-test for normally distributed measures, and through the Wilcoxon signed rank test for nonnormally distributed measures.

Potential effects of image exposure on changes in SART performance were investigated through a repeated-measures analysis of variance (ANOVA) for normally distributed measures. Where the ANOVA indicated statistically significant interactions, post-hoc analyses were carried using t-test statistics as only two exposure conditions were compared. The Box's test was used to check that the assumption of equality of covariance matrices was met. In addition, the assumption of equal variances was checked through the Levene's test of equality of error variance. Partial eta-squared was used to indicate effect size for ANOVA analyses, while Cohen's d was used for t-test and Rosenthal's *r* (calculated as absolute value of $Z/\sqrt{n_x+n_y}$) for nonparametric tests (Rosenthal, 1994).

## Results

### Older Sample Characteristics

The 75 participants in our sample (mean age: 68.6, *SD* = 8.3, median age = 67, IQR = 10, range =60-95; 56% female) were overall healthy: 38.2% reported no heart conditions and 37.3% reported one condition. 54.6% of the sample reported to be in good/very good health (on a scale from poor to excellent), 58.7% indicated good/very good eyesight, 49.3% good/very good hearing, and 57.3% good/very good memory. The mean SMSSE score for the sample was 28.8 (*SD* = 1.3, median = 29, IQR = 2).

80% of the participants reported at least secondary education attainment.

Half of the participants (46.7%) described their place of residence as “urban” (including inner city, city suburbs or towns) whereas the other half (53.3%) indicated residence in a “rural” place (i.e., village or countryside). Over 82% of the participants reported easy or very easy access to green spaces in their neighborhood of residence.

Considering changes in SART performance for the whole sample between Session 1 (pre-exposure) and Session 2 (post-exposure), there were no significant changes in terms of d-prime ($t_{74}$ = -1.31, $p$ = .19, Cohen’s $d$ = 0.15), reaction times ($t_{74}$ = 1.15, $p$ = .25, Cohen’s $d$ = 0.13), commissions ($Z$ = -0.09; $p$ = .92, $r$ = 0.01), or inverse efficiency ($Z$ = -1.83; $p$ = .07, $r$ = 0.14). Statistically significant changes were noted in terms of increased accuracy ($Z$ = -2.36; $p$ = .02, $r$ = 0.19) and decreased omissions ($Z$ = -2.73, $p$ = .006, $r$ = 0.22). However, both measures of effect size and an inspection of the sample performance in each session revealed that these changes were of a very small magnitude for accuracy (S1: median = 0.83, IQR = 0.16; S2: median = 0.84, IQR = 0.16), and small for omissions (S1: median = 18.3, IQR = 28; S2: median = 15, IQR = 29).

Participants were assigned in counterbalanced order to one of two exposure groups: natural (n = 38, 52.6% female) or urban scenes (n = 37, 59.5% female). The two exposure groups did not differ significantly in terms of age (natural exposure median age = 68, urban exposure median age = 66; $Z$ = -0.73, $p$ = .46, $r$ = 0.08), educational attainment ($Chi2_2$ = 2.26, $p$ = .32), SMMSE score ($Z$ = -0.66, $p$ = .51, $r$ = 0.07), or health (measured through *Chi2*: eyesight, $p$ = .92; hearing, $p$ = .62, memory, $p$ = .93; heart conditions, $p$ = .54, other health conditions, $p$ = .55). A significant difference was noted for self-reported health ($Chi2_4$ = 10.2, $p$ = .03, *Phi* = 0.37), whereby higher proportions of participants in the natural than urban exposure group indicated overall very good or excellent health.

Participants in the two exposure groups were evenly distributed in terms of urban or rural place of residence ($\text{Chi2}_1$ = 0.12, $p$ = .73), as well as access to green spaces ($\text{Chi2}_4$= 6.23, $p$ = .18).

**Changes in SART Performance by Exposure Group (Older Sample)**

Baseline comparisons between exposure groups in the older sample are reported in Table 1. The two groups differed significantly in terms of the number of errors of commission (wrongly pressing the bar when seeing the number three on the screen), with participants in the natural exposure group committing more baseline errors than those in the urban group ($p$ = .008). This measure was not included in subsequent analyses.

Table 1
*Baseline SART performance by exposure group (Older sample)*

| | Exposure | | | | |
|---|---|---|---|---|---|
| Dimension | Natural | Urban | Statistic | *P*-value | Effect size |
| d-prime[a], *M* (*SD*) | 0.51 (1.29) | 1.12 (1.41) | -1.96 | .054 | 0.45 |
| Reaction times[a] (ms), *M* (*SD*) | 433.1 (109.7) | 437.1 (125.2) | -0.15 | .88 | 0.03 |
| Accuracy[b], median (IQR) | 0.82 (0.16) | 0.83 (0.13) | -1.47 | .14 | 0.16 |
| Commissions[b], median (IQR) | 10.5 (6.25) | 6.0 (8.0) | -2.66 | .008 | 0.31 |
| Omissions[b], median (IQR) | 24.0 (24.0) | 17.0 (25.0) | -1.13 | .26 | 0.13 |
| Inverse efficiency[b], median (IQR) | 490.4 (268.6) | 454.2 (235.1) | -0.37 | .71 | 0.04 |

*Notes*.
a Results of a independent samples t-test are shown as *t* statistics, *p*-values and Cohen’s *d*
b Results of a Mann-Whitney test are shown as *Z* Statistics, *p*-values and Rosenthal’s *r*

Effects of exposure to natural vs. urban images on attentional performance were investigated for all measures except errors of commissions. Figure 1 shows comparisons of performance between and within groups for the older sample for all measures of interest.

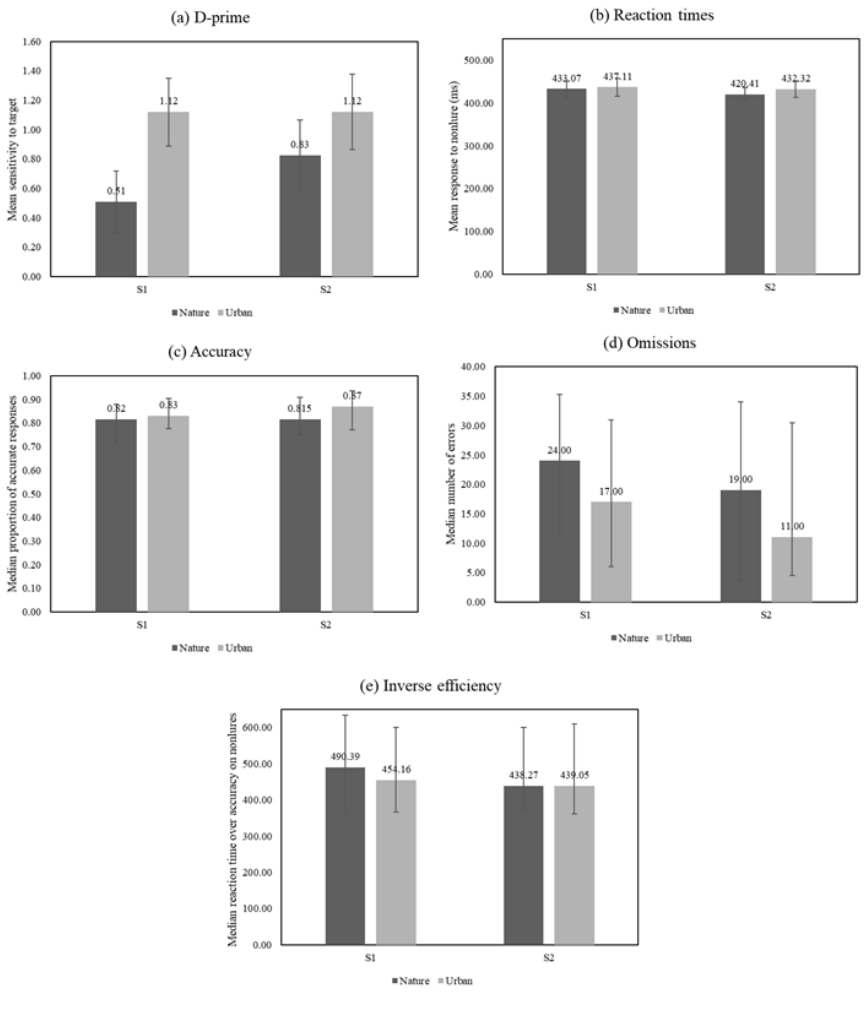


*Figure 1*. Comparisons of performance between exposure groups in the older sample at baseline and post-exposure and within each group pre- and post-exposure. Mean performance and standard errors are presented in (a) and (b), whereas median and interquartile range are presented for (c), (d), and (e).

A 2 X 2 ANOVA was conducted for d-prime and reaction times, as these measures met the assumptions of normality (see Supplementary File 2).

For d-prime, both the assumptions of equality of covariance matrices (Box's $M$ = 1.22, $p$ = .76) and of equality of variances (Session 1, Levene's $F_{1, 73}$ = 2.15, $p$ = .15; Session 2, Levene's $F_{1, 73}$ = 0.35, $p$ = .85) were met. The ANOVA showed no main effects of exposure group ($F_{1, 73}$ = 2.15, $p$ = .15, $\mu^2$ = 0.03) or session ($F_{1, 73}$ = 1.67, $p$ = .20, $\mu^2$ = 0.02) and no interaction effects ($F_{1, 73}$ = 1.67, $p$ = .21, $\mu^2$ = 0.02).

In terms of reaction times, once again the assumptions of equality of covariance matrices (Box's $M$ = 3.07, $p$ = .39) and of equality of variances (Session 1, Levene's $F_{1, 73}$ = 0.22, $p$ = .64; Session 2, Levene's $F_{1, 73}$ = 2.29, $p$ = .14) were met. The ANOVA indicated no significant main effects of session ($F_{1, 73}$ = 1.31, $p$ = .26, $\mu^2$ = 0.02) or exposure group ($F_{1, 73}$ = 0.11, $p$ = .75, $\mu^2$ = 0.001). In addition, no significant differences were noted in changes in reaction times at the SART between participants exposed to natural or urban images ($F_{1, 73}$ = 0.26, $p$ = .61, $\mu^2$ = 0.004).

As accuracy, omissions, and inverse efficiency did not meet the assumptions of normality, a Wilcoxon signed rank test was used to investigate changes pre- and post- image viewing for each exposure group separately. This indicated no statistically significant changes for any of the measures in the group exposed to urban images (within group accuracy: $Z$ = -0.89, $p$ = 0.37, $r$ = 0.07; omissions: $Z$ = -1.35, $p$ = .17, $r$ = 0.11; inverse efficiency: $Z$ = -0.64, $p$ = .52, $r$ = 0.05). In the group exposed to images of nature, the analyses indicated a small decrease in accuracy ($Z$ = -2.42, $p$ = .02, $r$ = 0.19), in the number of omissions ($Z$ = -2.43, $p$ = .02, $r$ = 0.19), and in inverse efficiency ($Z$ = -2.02, $p$ = .04, $r$ = 0.16). However, the size of these changes appeared to be small by inspecting the effect size values and the participants' median performance in Figure 1, particularly with regards to accuracy. In addition, a Mann-Whitney test indicated no statistically significant differences in performance between the two exposure groups after viewing the images (between groups accuracy: $Z$ = -0.98, $p$ = .32; omissions: $Z$ = -0.51, $p$ = .62; inverse efficiency: $Z$ = -0.07, $p$ = .94).

**Age-related Differences in SART Performance**

We pooled the data from our older sample with that of a younger sample who completed the same experiment to check for age-related differences in SART performance. Between-age groups comparisons at baseline (Session 1) and after exposure (Session 2) are shown in Figure 2. We found that the older sample had lower sensitivity than the younger group (Figure 2a: D-prime) both in Session 1 ($t_{94}$ = 2.86, $p$ = .005, Cohen's $d$ = 0.81) and Session 2 ($t_{94}$ = 2.04, $p$ = .044, Cohen's $d$ = 0.58). Older participants were slower than younger ones (Figure 2b: Reaction times) in Session 1 ($t_{94}$ = -3.58, $p$ = .001, Cohen's $d$ = 0.98) and Session 2 ($t_{94}$ = -2.88, $p$ = .005, Cohen's $d$ = 0.74). The older sample was also less accurate than the younger sample in terms of total accuracy (Figure 2c; Session 1: $Z$ = -4.97, $p$ = .000, $r$ = 0.51; Session 2: $Z$ = -4.71, $p$ = .000, $r$ = 0.48), omissions (Figure 2d; Session 1: $Z$ = -6.01, $p$ = .000, $r$ = 0.61; Session 2: $Z$ = -5.47, $p$ = .000, $r$ = 0.56) and inverse efficiency (Figure 2f; Session 1: $Z$ = -4.03, $p$ = .000, $r$ = 0.41; Session 2: $Z$ = -3.25, $p$ = .001, $r$ = 0.33). No age-related differences were found for errors of commission (Figure 2e; Session 1: $Z$ = -1.16, $p$ = .24, $r$ = 0.12; Session 2: $Z$ = -1.62, $p$ = .11, $r$ = 0.16).

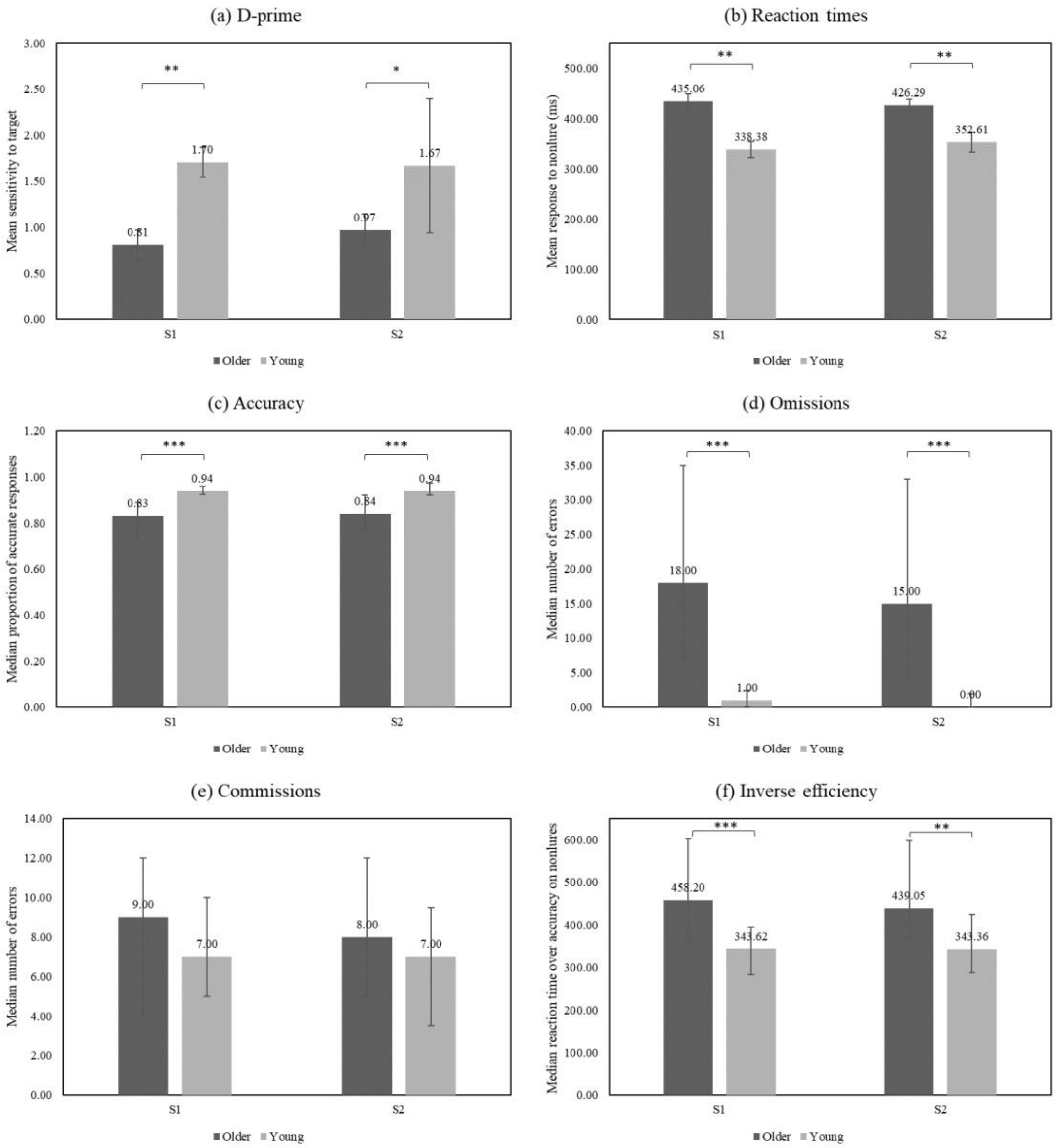


*Figure 2*. Comparisons of performance between age groups at baseline (S1) and post-exposure (S2). Mean performance and standard errors are presented in (a) and (b), whereas median and interquartile range are presented for (c), (d), (e) and (f). Statistical significance differences are presented as * *p* > .05, ** *p* > .01, *** *p* > .001.

## Discussion

Our study aimed to test ART on a sample of healthy older adults based on the experimental paradigm by Berto (2005), who had found that exposure to images of natural environments, as opposed to urban images, improved attentional capacity in young adults as measured by the SART. Our results indicate no differential effects on attention of exposure to natural vs. urban images: Participants exposed to images of nature experienced a small reduction in the number of omissions and in inverse efficiency, but these changes were of very small magnitude. Furthermore, their performance pre- or post- exposure did not vary significantly from that of participants who viewed urban images. The decrease in number of omissions for the overall sample pre- and post-exposure might indicate that the break offered during the environmental exposure could have equally restored attentional resources in both groups; however, this change was minimal. It could be argued that using a shorter version of the SART might have been insufficient to cause attentional fatigue in the participants; however, it should be noted that SART produces very rapid effects of fatigue, indicated by lapses of attention, i.e. errors, under four minutes as indicated by a comprehensive lifespan review on sustained attention (Staub et al., 2013). A previous study using SART with older people, was 5.4 minutes long, and utilized a slower pace, which, should be less depleting for attentional resources, according to the Resource Depletion theory (Staub et al., 2013) and registered poorer performance in older than in younger adults (McAvinue et al., 2012). Our comparisons between older and younger participants showed a consistently poorer performance in the older than younger group, indicating that our older participants found the task more difficult to complete. In addition, the younger group involved in our study had similar performance to that presented in Berto (2005), who included undergraduate students (see Table 1 in Berto, 2005). Furthermore, the response times of our older sample were in line with Carriere et al. (2010), therefore it is unlikely that performance was at ceiling in the present study. The older sample showed overall increased accuracy and decreased omissions pre- and post- exposure; while practice effects cannot be entirely excluded, these changes were very small and did not occur for other measures of interest. Considering previous studies, Gamble et al. (2014) found a practice effect in the Backwards Digit Span, whereas McAvinue et al. (2012) did not report any practice effects in the SART. One possible explanation for our study is that the depletion of attentional resources potentially occurring in Session 1 was compensated for by the practice effect, with no modulation by environment type.

An important consideration with regards to our results is related to the design of the environmental exposure in our experiment. Each exposure group in our sample viewed eight environmental scenes; in comparison, Berto (2005) exposed the participants in each group to 25 scenes, and Gamble et al. (2014) used 50 pictures for each group. Being exposed to fewer images of environmental scenes might have not allowed for the restorative effects to emerge. We selected eight images for each group based on ratings of restorative qualities out of a pool of 15 which were rated for restorativeness; nonetheless, this is a limitation of our study which points at the need for a clear operationalization of dose-response effects of nature in an experimental paradigm (Taylor & Hochuli, 2017), and poses the question on what minimum number of images is needed to elicit restorative effects. This may indicate that the element of novelty is important in attention restoration, which points towards an important role of familiarity (or familiarization with the scene), which had not been full consideration in the current literature (Hernandez, Hidalgo, Berto, & Peron, 2001). Furthermore, the specific images selected for this study could have influenced the absence of a restorative effect. Gatersleben & Andrews (2013), for example, found that images of natural environments low in prospect (i.e., clear field of vision) and high in refuge (i.e., places where to hide) were not rated as restorative. However, in our pre-test survey pictures of forests received higher ratings of restorativeness, Nonetheless, a more in-depth and multi-factorial analysis of physical attributes linked to preference and restoration can improve the level of control in the selection of environmental scenes, as recently suggested by Hunter & Askarinejad (2015). This however points towards the need to understand whether prospect and refuge are determinants of cognitive restoration, which deserve further investigation. To address this issue, open access to databases of environmental scenes that have been used in previous experimental studies testing ART could promote replicability and comparison between different restoration conditions.

A consideration on the universality of the effects of cognitive restoration is also granted: There is a possibility that macro-level geographical and cultural factors might influence the potential restorative effects of natural or urban settings. Staats et al. (2016), for instance, found that country of residence moderated the perceived restorative potential of environmental scenarios, despite their sample involved participants with similar socio-demographic profile from three Western countries. In our study we tested attention restoration in a sample from the south-western region of Ireland which is characterized by high availability of natural spaces; this was confirmed by the fact that over 80% of our participants indicated easy or very easy access to green spaces with no differences between participants living in urban or rural settings. A growing body of evidence has shown that urban and rural living can be linked to variations in cognitive health in ageing (Besser et al., 2018; Cassarino & Setti, 2015; Weden, Shih, Kabeto, & Langa, 2018; Wörn, Ellwardt, Aartsen, & Huisman, 2017; Wu et al., 2015) which suggest that the place of residence can act on older people as a long-term form of environmental exposure (Oswald & Wahl, 2005). Although our sample included people living in urban and rural places, it did not include participants from highly urbanized places, thus limiting our ability to fully investigate the potential moderating effects of place of residence, whereas we have previously shown that population density is a determinant of cognitive performance in ageing (Cassarino, O'Sullivan, Kenny, & Setti, 2018). Importantly, this consideration highlights the need for a better operationalization of the dose of nature (in terms of both length and type of exposure) that can effectively promote cognitive restoration in light of socio-demographic and lifestyle circumstances (Taylor & Hochuli, 2017).

A clearer operationalization of the nature both in terms of interaction (in vivo vs. image exposure), dose (duration of exposure, type of nature) and outcomes (e.g., cognitive, physical health), although difficult to achieve, is needed in order to better understand how nature contact can be capitalized upon to improve health and wellbeing.

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## Statements

**Acknowledgments**

Part of this work constitutes the MA in Applied Psychology thesis of Isabella C. Tuhoy and the Final Year Project of Paddy Lynch, both supervised by Annalisa Setti. The authors wish to thank Mary Collins, Paddy Lynch and Isabelle O'Driscoll for their help with data collection.

**Funding**

This research did not receive financial support.

**Disclosure of potential conflicts of interest**

The authors declare that there is no conflict of interest.